

## What Is Claimed Is:

1           1.     A finger print minutiae extraction method comprising:  
2                 acquiring fingerprint image data;  
3                 partitioning said fingerprint image data into at least one data block  
4     corresponding to a local area of said image data;  
5                 generating a histogram function of a contrast level of said image data  
6     corresponding to said data blocks; and  
7                 performing a histogram transformation of said histogram function,  
8                 wherein said histogram transformation is adapted to the contrast level of  
9     said local area of said fingerprint image data and pre-enhanced fingerprint image data  
10    is generated with local enhancement.

1           2.     The method of claim 1, further comprising:  
2                 partitioning said fingerprint image data into a plurality of data blocks, each of  
3     said plurality of blocks corresponding to a different local area of said image data and at  
4     least one of said plurality of blocks having a contrast level different than a second of said  
5     plurality of data blocks,  
6                 wherein said histogram transformation is adapted to said different  
7     contrast levels of said plurality of blocks and pre-enhanced fingerprint image data is  
8     generated with local enhancement for a plurality of local areas of said image data.

1           3.     The method of claim 1, wherein said histogram transformation includes  
2     using an objective function with a relatively high value at both endpoints of an intensity  
3     interval and a relatively low value at a middle of said intensity interval.

1           4.     The method of claim 1, wherein noise and distortions in said image data  
2     are reduced.

1           5.     The method of claim 1, wherein said histogram transform maps said  
2 histogram function to a specific function according to a mapping algorithm including

$$3 \quad x \mapsto \arg \min_y \{y \mid \int_0^x g(t) dt < f(y)\}$$

4           wherein  $f(x)$  is a target histogram function and said target histogram function has  
5 low value at the mid-point and has a high value at the endpoint of the interval.

1           6.     The method of claim 1, further comprising:  
2           performing orientation filtering on said pre-enhanced data using  
3 directional convolution for two dimensional digital image processing,  
4           wherein said pre-enhanced image data is smoothed and enhanced.

1           7.     The method of claim 6, wherein the following algorithm is used in said  
2 orientation filtering

$$3 \quad g(i, j, k) = \sum_{l=1}^M f(i + y_{offset}(l), j + x_{offset}(l)) \times h(l).$$

1           8.     The method of claim 1, further comprising:  
2           thinning said fingerprint image data to remove false connections of ridges  
3 in said data,  
4           wherein said thinning includes applying a first table and a second table to  
5 a plurality of pixels using an algorithm.

1           9.     The method of claim 1, further comprising generating a first table and a second  
2 table using rules for character data and biological data.

1           10.    The method of claim 9, wherein said rules for biological data include  
2           If  $P_1 * P_7 * P_8 = 1$  and  $P_2 + P_6 > 0$  and  $P_3 + P_5 = 0$  then  $LUT_1(P) = 0$ ;  
3           If  $P_5 * P_6 * P_7 = 1$  and  $P_4 + P_8 > 0$  and  $P_1 + P_3 = 0$  then  $LUT_1(P) = 0$ ;  
4           If  $P_1 * P_2 * P_3 = 1$  and  $P_4 + P_8 > 0$  and  $P_5 + P_7 = 0$  then  $LUT_2(P) = 0$ ; and  
5           If  $P_3 * P_4 * P_5 = 1$  and  $P_2 + P_6 > 0$  and  $P_1 + P_7 = 0$  then  $LUT_2(P) = 0$ ,

6 wherein A(P) is a number of 0-1 patterns in an order set  $P_1, P_2, P_3, P_4, P_5, P_6,$   
7  $P_7, P_8, P_1$ , where  $P_i, i=1, \dots, 8$ , are 8-neighbors of a pixel in a clockwise direction, and  
8 B(P) is a number of nonzero neighbors of P.

1 11. A method for fingerprint registration and verification from minutiae comprising:  
2 performing a Hough transform on fingerprint image data and generating  
3 evidences in lattice bins;  
4 counting the evidences accumulated in said lattice bin;  
5 shifting a lattice;  
6 determining the number of evidences in each bin of said shifted lattice;  
7 repeating said shifting and counting in each direction of said lattice until a  
8 bin is completely overlapped with its diagonal neighbor,  
9 wherein shifting the lattice enhances the spatial resolution of the Hough  
10 transform.

1 12. The method of claim 10, wherein said shifting said lattice occurs at a  
2 predetermined step size.

3 13. The method of claim 10, wherein said shifting the lattice partitions each  
4 bin into blocks, each block is assigned a number equal to the number of evidences  
5 in the corresponding bin, the numbers of the overlapped blocks are summed and  
6 transform parameters are specified using the block that corresponds to the highest  
7 sum.

1 14. The method of claim 10, further comprising:  
2 determining the maximum number of evidence counts in the bins;  
3 determining transformation parameters corresponding to the bins with the  
4 maximum evidence counts;  
5 determining the variance of said transformational parameters;  
6 determining a matching score of a fingerprint image and a template  
7 fingerprint image based on said variance of the transformational parameters and said  
8 maximum number of counts.

1 15. The method of claim 13, wherein the matching score is determined using a  
2 sigmoid nonlinear function.

1 16. A system for biological data matching comprising:  
2 an image reader for acquiring personal biological image data;  
3 a template of biological image data;  
4 a pre-enhancing unit adapted to pre-enhance said personal biological  
5 image data according to local and global areas of contrast;  
6 an image smoothing and enhancement filter for enhancing said pre-  
7 enhanced image data;  
8 an orientation data thinner for removing false data in said personal  
9 biological image data;  
10 a registration unit for aligning said personal biological image data with  
11 said template image data; and  
12 a matching score generating unit for determining if said biological data  
13 matches said template print.

1 17. The system of claim 15, wherein said personal biological image data and  
2 said temple image data include a fingerprint, iris, voice, hand geometry, face, or palm  
3 pattern.

1           18. The system of claim 15, further comprising:  
2           a database including a plurality of templates of biological image data,  
3           wherein said system determines which template of said plurality of  
4 templates in said database matches said personal biological image data.

1           19. The system of claim 15, wherein said registration unit aligns said image  
2 data with said template using a Hough transform and shifts a lattice to enhance the  
3 spatial resolution of the Hough transform.

1           20. The system of claim 15, wherein said pre-enhancing unit enhances local  
2 areas of contrast by partitioning said image data into image data blocks, generating  
3 a histogram function of a contrast level of said image data corresponding to said  
4 data blocks, and performing a histogram transformation of said histogram function.